Nanotechnology: Perspectives from the IEC TC 113 on Nanotechnology

Standards and Measurements to Accelerate Innovation

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Outline

- **Attributes of Nanotechnology**
- **IEC TC 113 Status**
- **Proposed TC 113 Taxonomy Survey**
- **Environmental, Health, and Safety Opportunities and Challenges**
- **NIST USMS Assessment**
- **Conclusion – Discussion – Key Message**

Nanotechnology standards are significant for success at all stages of innovation.

Global competition is intense: Imperative for the best of each nation's technology to be included in internationally-developed specifications and standards.

Innovation in nanotechnology depends on standards based on solid science and engineering: Standards not so based may constrain innovation and entrench inadequate technologies. Documents on consensus specifications advance the field.

Standards are key to success in addressing the highly multi-disciplinary and broad-based nature of nanotechnology

EHS standards influence R&D and business models: Environmental, health, and safety standards are a high priority on agendas for responsible development of nanotechnology.

Adapted from presentation slide by E. C. Teague, Workshop on Nanoinformatics Strategies, Arlington, VA, June 12-13,2007

Nanotechnology:
Converging and Emerging of Many Technologies

Examples:

nanoelectronics, molecular electronics, information technology, robotics, artificial intelligence, and advanced medical imaging (extracting quantitative health parameters from computer assisted interpretations of images) – [Carbon nanomaterials (CNTs), Fullerene-like molecules, nanowires, quantum dots, dendrimers, and nanoporus/hollow material].

Attributes:

Fast moving,
Potentially disruptive,
Meet diverse market and industry needs,
Many international players and stakeholders – but none is dominant and not localized to one region, and
Numerous disciplines contribute.

Nanotechnology:
Converging and Emerging of Many Technologies

Challenges:

Involve relevant players and stakeholders in international standards – Global collaborations and cooperation will be key.

Establish decision making procedures.

Build consensus and priorities to accommodate limited resources.

Account for varying national and regional priorities.

Decision Making for Nanotechnology Standards

Input averaging from many experts based on collective wisdom techniques has advantages for standards development in nanotechnology that involves many diverse disciplines.

A lesson from the semiconductor industry – production became resource limited and too expensive for each economy to support the entire infrastructure (e.g., lithography) so the international semiconductor industry now shares pre-competitive R&D resources.

A GRAND CHALLENGE

Coordination with all the global stakeholders - the overload of overlaps or Who is doing what?

Just in the area of nanotechnology, TCs for ISO and IEC co-exist with:
ITU
OECD
JEDEC JC-14 Quality and Reliability – before 2001
IEEE Standard Test Methods for Measurement of Electrical Properties of Carbon Nanotubes - 2005
ASTM International Committee E56 on Nanotechnology – 2005
IEEE-SA (STD 1650 – 2005 and NESR – 2007)
ANSI NSP - 2005
And this list go on and on and on ……. .

IEC TC 113 on
Nanotechnology Standardization for Electrical and Electronic Products and Systems

Proposed Short Title:
IEC TC 113 on Nano-electro-technology

Scope: Standardization of the technologies relevant to electrical and electronic products and systems in the field of nanotechnology in close cooperation with other committees of IEC and ISO TC 229.

Present Status of TC 113

Current TC 113 Working Groups

- JWG 1: Joint Working Group: Terminology and nomenclature, with ISO TC 229 Nanotechnology (ISO and IEC Co-Conveners)
- JWG 2: Joint Working Group: Measurement and characterization, with ISO TC 229 Nanotechnology (ISO and IEC Co-Conveners)
- WG 3: Performance Assessments (Electrotechnical Components, Subassemblies, and Systems) (IEC Convener)

Other proposed Working Groups

- WG 4: tbd (perhaps: Environment, Safety, and Health to complement ISO TC 229 Nanotechnology)

The Diffuse TC113/TC229 Moving Boundary

IEC TC 113 WG3 -- Market demand, technology pull – emphasis on performance, reliability, process control, durability, disposal, and recycling

→ **Nano-function Attributes – conductivity, resistance, failure rates, strength,**

Diffuse Moving Boundary

IEC TC 113 ↘

JWG2 -- Technology push from R & D to innovation - emphasis on metrology

ISO TC 229 ↗

→ **Nano-composition Attributes – elemental make-up, dimensions, structure, morphology**

Moving nano-electro- technology towards commercialization

Present Status of TC 113 (continued)

Taxonomy Survey –

Goal is to begin building a consensus among members of the nano-electro-technology community on a framework leading to standards development. This consensus will help the Technical Committee to:

- **Set procedures for ranking new work item proposals (NWIPs) in priority order.**
- **Identify members for work groups to complete high priority new work item proposals.**
- **Respond to new work item proposals from IEC National Committees.**

TC 113 Survey - Nano-electro-technology Taxonomy

Electronics directed to Computer, and Computer Peripherals
Optical Technologies, Optoelectronics, Illumination
Multimedia Consumer Electronics
Telecommunications (Telemedicine)
Energy Production, Conversion and Storage
Life Science, Medical Products and Healthcare Delivery
Fabrication, Test Equipment and Industrial Process Control
Household and Consumer Appliances
Transportation, Automotive, Aviation and Space Technologies
Security Technologies
Environmental Technologies
Bioelectronics, Nanobiology, Electronic-Biologic Interfaces
Magnetics and Electromagnetics
Electroacoustics
Microsystem Technologies, MEMS, Sensors
Material Technologies for Electrotechnical Applications

Proposed Nanotechnology Product Inventory

We do not have adequate quantitative product data and trends as inputs for:

- **Setting priorities and allocating resources.**
- **Identifying standards and measurements appropriate for ISO and IEC.**

Undertake an inventory of products and systems based on converging and emerging technologies; perhaps starting with electrical, electronic, optical, and magnetic products and systems that contain nanoscale components or will likely contain them.

Proposed Nanotechnology Product Inventory
(continued)

Do the product inventory and validate the nanotechnology content of what is in the marketplace today, and then for What is expected to be in the marketplace by 2012.

This inventory could:

- **Reinforce direction and scope of selected IEC TCs.**
- **Motivate and engage the technical community to pursue appropriate measurement and standardization activities.**

Environmental, Health, and Safety (EHS) International Opportunities and Challenges

In U.S. – no single agency has jurisdiction over nanomaterials

- **OSHA - during manufacture**
- **FDA - drug and device**
- **EPA - end use**

Balance between proceeding with some innovations and not proceeding other innovations – How will the global society decide?

In other nations

In other regions - Europe, Asia, and the like

Environmental, Health, and Safety (EHS) International Opportunities and Challenges

EHS at each stage of the Nanomaterials Cycle

Raw and/or Recycled Material → Process → Subassembly → System Integration → Product → End Use → End-of-Life → (Disposing and Recycling)

Who is responsible for EHS at each stage?

Who determines measurements and standards for benefits and risk management at each stage?

Will they be traceable to national measurement institutes?

Environmental, Health, and Safety (EHS) International Opportunities and Challenges

One randomly selected example from *NanoToday*, October 2007, Volume 2, Number 5, page 10:

Carbon nanotubes show germ-fighting promise

Toxicology and Environment

Researchers from Yale University have provided the first direct evidence that highly purified single-walled carbon nanotubes (SWNTs) exhibit strong antibacterial activity [Kang et al., Langmuir (2007) 23, 8670]. This has implications for both useful antimicrobial filtering processes and possible harmful environmental effects. … contact with nanotubes results in the death of the bacteria. … After exposure, loose DNA and RNA were found floating in the solution, …., causing this genetic material to float out.

What is the mechanism that leads to leakage of genetic material? – local inflammation, puncturing, etc. ?

Environmental, Health, and Safety (EHS) International Opportunities and Challenges

Nanoliteracy for regulators and general public
(a nano-*Jaws* like movie may add challenges to business models for nanotechnology)

Strengthen the complex relationship between nanotechnology and EHS regulation

e.g., nanosilver as an early test case - "stay fresh longer" or "kills germs": Over 100 products on WWIC PEN list contain nanosilver according to manufacturers. How many more products, not on the list, contain nanosilver? After independent testing to validate manufacturers' claim, how many products on the list do not contain nanosilver?

Are nanosilver releasing appliances devices (in U.S., Toxic Substance Control Act) or pesticides (in U.S., Federal Insecticide, Fungicide, and Rodenticide Act)?

Bone Tissue Engineering [1]

Single-walled carbon nanotube scaffolds promote differentiation of progenitor osteoblast cells into functional mature osteoblast cells (bone forming cells) – increase bone mineral density in patients with osteoporosis

Carbon nanotubes promote bone cell proliferation, show excellent affinity for cell adhesions and enable high bone cell proliferation and production of hydroxyapatite crystals; and chemically functionalized SWCNTs with negatively charged surface control the orientation of the nuclei of hydroxyapatite and promote the crystal growth.

Establishes direct relationships among SWCNTs, their electronic charge distributions, and bone health biomarkers.

[1] Xiaomin Tu, et al., Department of Chemistry, University of Arkansas Little Rock,
Paper presented at MRS Spring Meeting 2007, San Francisco

WILL MEASUREMENT NEEDS FOR TECHNOLOGICAL INNOVATION IN NANOTECHNOLOGY BE MET?

A Brief Look
at the NIST Assessment of the
U.S. Measurement System (USMS)

NIST Report on its Assessment of the USMS is available for download at

http://usms.nist.gov/usms07/usms_assessment_report_2006.pdf

Appendix B contains more than 50 nanotechnology measurement needs that span the scopes of both ISO 229 and IEC 113.

http://usms.nist.gov/usms07/appendix_b_usms_report_%202006.pdf

Key Messages

Nanotechnology has unique attributes

Many international contributors

All SDOs should collaborate to use the world's limited number of technical experts most effectively

SDOs should educate the public about EHS aspects of nanotechnology – otherwise the nanotechnology business model may be similar to nuclear and genetically modified organism industries

THANK YOU